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IMPROVEMENT OF GHIRKA SPRING WHEAT IN YIELD AND QUALITY.

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INTRODUCTION.

A demand for hardier and more drought-resistant wheats was created with the progress of settlement of the drier portions of the Great Plains area. In response to this demand, the United States Department of Agriculture began about 1898 to improve the wheat crop of that area by the introduction from eastern and southern Russia of varieties which were thought to possess hardiness and drought resistance. To determine the value of these varieties they were tested at agricultural experiment stations in different localities in the Great Plains area. The principal economic result of this work was the introduction of Kharkof winter wheat and Kubanka durum wheat.[1]

Some of the other varieties obtained were found of value for dry-land areas. Among them was the Ghirka Spring wheat, which was both productive and drought resistant, but comparatively low in milling value. Its improvement in yield and quality is the subject of the present paper.

[1] Carleton, M. A. Hard wheats winning their way. *In* U. S. Dept. Agr. Yearbook, 1914, p. 391–420, fig. 22–25, pl. 35–41. 1915.

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HISTORY AND DESCRIPTION OF GHIRKA SPRING WHEAT.

The Ghirka Spring is the principal variety of beardless red spring wheat grown in Russia, particularly in southern Russia and the Volga River district. It forms a large part of the wheat exported from Russia.[1] This wheat has been introduced into this country several times. During the period from 1898 to 1904, inclusive, eight lots were obtained by the Office of Cereal Investigations of the United States Department of Agriculture. These lots are recorded as Cereal Investigations Nos. 1046, 1047, 1051, 1192, 1517, 1534, 2644, and 2646.

Other importations of this variety of wheat have been made by Russian immigrants. Joseph Dukart, who settled at New England, N. Dak., brought a 2-pound lot from Russia in 1905. From the

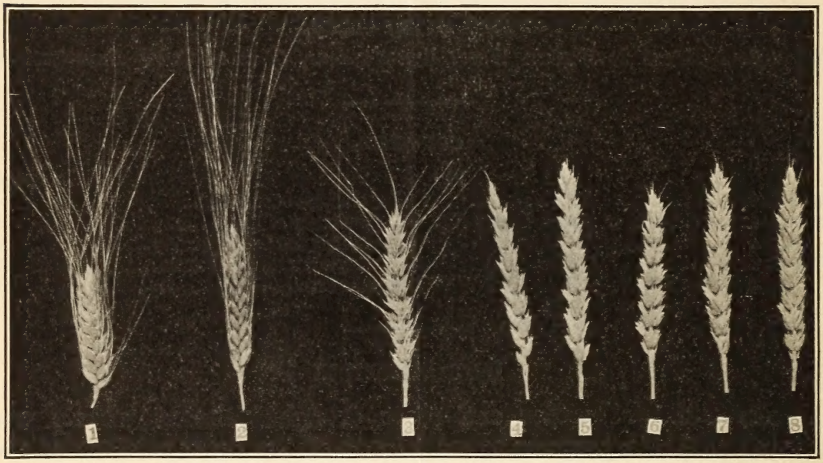

FIG. 1.—Heads of eight varieties of wheat grown at the Dickinson substation: (1) Kubanka durum; (2) Arnautka durum; (3) Preston; (4) Ghirka Spring; (5) Rysting Fife; (6) Marquis; (7) Crossbred Bluestem; and (8) Haynes Bluestem.

increase of this, several thousand acres are now grown annually in western North Dakota as "Russian" wheat. So far, however, the variety has never become commercially important in this country, though its acreage may be expected to increase.

The Ghirka Spring wheat has been placed in the Fife group of spring common wheat by most writers, as its characters are essentially the same as those of the varieties of that group (fig. 1). It differs from the Red Fife varieties in that it is earlier, has pubescent leaves, and the spike is a little more slender and distinctly more tapering at the tip. The kernel is slightly longer, a paler red, and a little softer.

[1] Carleton, M. A. Triticum vulgare. Ghirka. *In* U. S. Dept. Agr., Bur. Plant Indus. Bul. 66 (Seeds and plants imported), no. 6002. 1905.

There is a variety known as Ghirka Winter (C. I. No. 1438), which apparently differs from Ghirka Spring only in the winter habit and in having a shorter, stouter spike.

EXPERIMENTS.

This paper contains the results of experiments with only one of the department's introductions, Ghirka Spring (C. I. No. 1517) from Grodno Province in Russian Poland.

The experimental data are discussed under three separate topics, yield, quality, and improvement. The yield of the original unselected Ghirka Spring wheat is compared with that of three standard varieties at a series of seven stations during a period of seven years. The milling and baking qualities also are compared with those of the same three standard varieties grown at the Dickinson (N. Dak.) substation during three different years. Finally, the progress being made in improving both yield and quality by pure-line selection is shown.

COMPARATIVE YIELDS.

Ghirka Spring wheat has been tested in comparison with other domestic and foreign wheats at several agricultural experiment stations in the Great Plains area. Some of these tests have been conducted by the State stations, some by the United States Department of Agriculture, and some by the two in cooperation.

At the time this wheat was included in the varietal tests at the experiment stations in the northern part of the Great Plains, Bluestem and Fife were the standard wheats grown in that district, while durum wheat was becoming better known and its acreage increasing. The experiment stations were testing several varieties and strains of Fife and Bluestem wheats and many new varieties of durum wheat which were then being imported. The object of these varietal experiments was to determine which group of wheat was best adapted to each locality.

The work at the start was considered a local problem. The varietal tests at each station were practically independent of those at any other. As the work progressed, the best adapted groups and varieties became more and more evident at each testing station. When the results from all the stations in one part of this area are compared only group adaptations usually are shown. The best variety in each group has been not always the same at all stations. In some cases the variety leading at one station has not been grown at some of the other stations or, if grown, has been discarded if the yields were not satisfactory. For these reasons it is difficult to compare the results from individual varieties at a group of stations. It is possible, however, to present yields of Ghirka Spring wheat (C. I. No. 1517) from seven experiment stations in the northern Great Plains during the

period of seven years from 1908 to 1914, inclusive. Yields of Kubanka durum wheat (C. I. No. 1440) and Haynes Bluestem wheat (C. I. No. 2874, Minn. No. 169) for the same years at the same stations are given for purposes of comparison.

It is desirable to compare the performance of Ghirka Spring with that of some other Fife wheat, but no one variety of Fife wheat other than Ghirka has been grown at all of the seven stations during this entire period. However, the Rysting Fife (C. I. No. 3022) has been grown at more stations during the period than any other variety of this group and is chosen for comparison. Yields of Glyndon Fife (C. I. No. 2873) have been substituted at the stations where the Rysting was not grown. The two varieties are very similar in appearance and are only different strains of Fife wheat.

The seven stations for which results [1] are presented are Moccasin, Mont.; Williston, Dickinson, and Edgeley, N. Dak.; and Brookings, Highmore, and Newell, S. Dak. The location and elevation of these stations are shown in figure 2. At all the stations except Edgeley, the work was conducted cooperatively by the United States Department of Agriculture and the State experiment stations. At Edgeley the tests were conducted entirely by the State, and the results given are quoted from the published annual reports of that substation for 1908 to 1913, inclusive. The results for 1914, not yet published, were kindly furnished by O. A. Thompson, superintendent of the Edgeley substation.

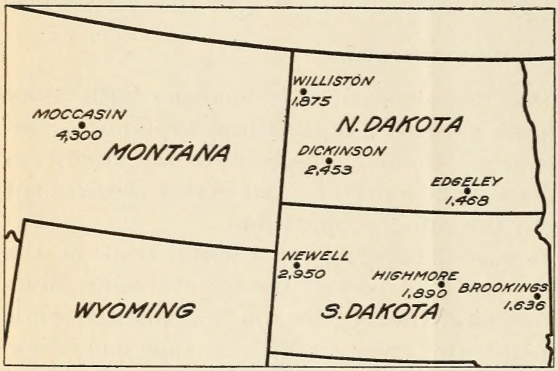

FIG. 2.—Sketch map of the northern Great Plains area, showing the location and elevation (in feet above sea level) of the seven experiment stations, results from which are discussed in this paper.

The annual and average yields of four varieties of wheat, Kubanka durum, Ghirka Spring, Rysting or Glyndon Fife, and Haynes Bluestem, grown at seven northern Great Plains experiment stations for the 7-year period from 1908 to 1914, inclusive,[2] are shown in Table I. The average yield of each variety for each station and also the average for all stations are shown graphically in figure 3.

[1] These data have been accumulated at the various stations by the following members of the scientific staff of the Office of Cereal Investigations: Manley Champlin (Brookings, S. Dak.); Charles H. Clark, J. A. Clark, and R. W. Smith (Dickinson, N. Dak.); J. D. Morrison (Highmore, S. Dak.); E. L. Adams and N. C. Donaldson (Moccasin, Mont.); Cecil Salmon and J. H. Martin (Newell, S. Dak.); and F. R. Babcock (Williston, N. Dak.).

[2] The manuscript of this bulletin was prepared in the spring of 1915, but publication has been unavoidably delayed. This bulletin includes experimental results only to the end of 1914.

The season of 1908 was a favorable one in regard to rainfall at all the stations here considered. Rather conflicting results were obtained with the Ghirka wheat at the different stations. The principal agreement in the tests was the outstanding yield of the Kubanka, surpassing the other varieties of wheat at Williston, Brookings, Highmore, and Newell, and equaling the yields of the Haynes and Ghirka Spring for first place at Moccasin and Dickinson, respectively. The Ghirka outyielded the other varieties at Edgeley, but, on the other hand, gave the lowest yield at Brookings, Highmore, and Newell. The exceptionally low yield of the Ghirka at Highmore and Brookings was due, in part at least, to rust. The average yield at the seven stations showed Kubanka first, Rysting-Glyndon second, Haynes third, and Ghirka fourth.

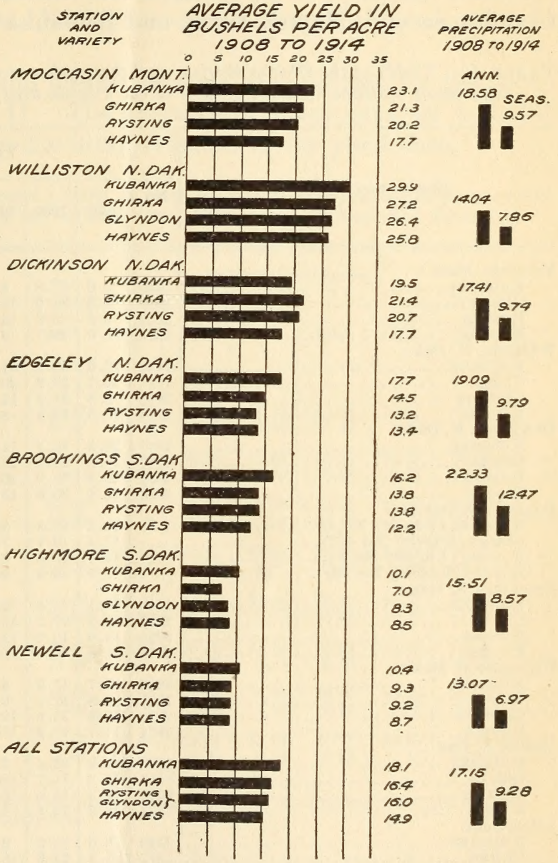

FIG. 3.—Diagram showing the average yields of four varieties of spring wheat and the annual and seasonal precipitation at seven experiment stations in the northern Great Plains area for the 7-year period from 1908 to 1914, inclusive.

The season of 1909 was unusually favorable at all the stations. Kubanka durum wheat gave the highest yields at Moccasin, Williston, Dickinson, Edgeley, and Newell. The Ghirka led at Brookings and Highmore, ranked second at Moccasin, third at Williston, and fourth at Dickinson, Edgeley, and Newell. Under the humid conditions of this year rust again caused a reduction in the yield of the Ghirka. For all stations the Kubanka ranked first, Ghirka second, Haynes third, and Rysting-Glyndon fourth.

The dry season of 1910 reduced the yields at all stations, and the results were entirely different from those obtained in previous years.

The Kubanka produced relatively low yields at all stations. This was caused by the sterility of the florets, probably induced by a combination of drought factors.[1] The Ghirka ranked first in yield at Moccasin, Williston, Dickinson, and Newell; second at Edgeley and Brookings; and fourth at Highmore. The results of this year showed that the Ghirka variety possessed real value as a drought-resistant wheat. For all stations the Ghirka ranked first, Rysting-Glyndon second, Haynes third, and Kubanka fourth.

TABLE I.— *Yields of the Ghirka Spring and three other varieties of wheat grown at seven experiment stations in the northern Great Plains area, 1908 to 1914, inclusive.*

Station and variety.	C. I. No.	Yield per acre (bushels).							
		1908	1909	1910	1911	1912	1913	1914	Average.
Moccasin, Mont.:									
Kubanka	1440	5.0	37.8	8.8	33.0	(a)	30.7	23.0	23.1
Ghirka	1517	3.3	34.2	13.2	25.2	(a)	29.0	23.0	21.3
Rysting	3022	2.5	29.0	13.0	27.0	(a)	26.7	23.0	20.2
Haynes	2874	b 5.0	29.7	9.1	18.7	(a)	c22.8	c18.6	17.7
Williston, N. Dak.:									
Kubanka	1440	12.6	39.1	11.0	8.9	51.0	33.0	53.8	29.9
Ghirka	1517	c10.7	33.2	20.2	12.1	51.7	22.2	40.4	27.2
Glyndon	2873	9.8	31.2	13.9	8.0	44.7	28.2	49.2	26.4
Haynes	2874	10.5	34.3	8.8	b9.2	44.3	30.0	42.5	25.8
Dickinson, N. Dak.:									
Kubanka	1440	23.5	33.7	14.9	3.8	(a)	26.7	14.2	19.5
Ghirka	1517	23.5	28.9	28.6	9.5	(a)	26.6	11.3	21.4
Rysting	3022	22.3	33.0	20.7	7.7	(a)	28.1	12.4	20.7
Haynes	2874	21.4	30.0	13.1	8.6	(a)	24.8	8.3	17.7
Edgeley, N. Dak.: d									
Kubanka (Edgeley No. 6)	.....	11.5	27.8	5.8	2.3	34.5	25.1	17.0	17.7
Ghirka (Edgeley No. 162)	.....	12.4	19.7	7.9	2.0	20.1	30.6	9.0	14.5
Rysting (Edgeley No. 3)	.....	10.1	20.3	6.2	1.6	21.7	25.2	7.0	13.2
Haynes (Edgeley No. 46)	.....	7.9	19.9	9.0	2.0	23.5	27.8	4.0	13.4
Brookings, S. Dak.:									
Kubanka	1440	16.1	11.8	12.7	1.2	28.0	28.3	15.0	16.2
Ghirka	1517	8.8	17.7	16.2	.8	18.0	26.7	c 8.7	13.8
Rysting	3022	14.9	15.5	16.9	3.0	16.8	20.0	9.2	13.8
Haynes	2874	11.6	16.9	15.7	2.8	15.8	20.2	2.5	12.2
Highmore, S. Dak.:									
Kubanka	1440	22.7	17.0	8.0	0	1.1	2.0	19.7	10.1
Ghirka	1517	4.8	17.7	6.2	0	2.4	6.5	11.3	7.0
Glyndon	2873	13.9	15.8	12.2	0	0	8.7	7.3	8.3
Haynes	2874	14.7	17.2	10.0	0	2.1	b7.7	7.5	8.5
Newell, S. Dak.:									
Kubanka	1440	24.9	21.4	5.3	0	0	15.6	c 5.9	10.4
Ghirka	1517	16.2	11.7	12.8	0	1.9	16.3	c 6.1	9.3
Rysting	3022	19.3	15.0	10.3	0	0	15.0	5.1	9.2
Haynes	2874	18.3	13.8	9.0	0	0	14.1	5.1	8.7
All stations:									
Kubanka	1440	16.6	26.9	9.5	7.0	22.9	23.1	21.9	18.1
Ghirka	1517	11.4	23.3	15.0	7.1	18.8	22.5	16.8	16.4
Rysting	3022	13.3	22.8	13.3	6.8	16.6	21.6	17.7	16.0
Glyndon	2873								
Haynes	2874	12.8	23.1	10.7	5.9	12.2	21.1	14.1	14.9

a Destroyed by hail in 1912.
b Yield of Haynes Bluestem (C. I. No. 3021, Minn. No. 51).
c Computed from the yields of the other varieties shown.
d Results from State substation; work not cooperative. Edgeley numbers and C. I. numbers represent the same original stocks.

A second successive dry season occurred in 1911 at all stations except Moccasin. There a plentiful rainfall caused the production of large yields. Under the favorable conditions at Moccasin, the

[1] Salmon, Cecil. Sterile florets in wheat and other cereals. *In* Jour. Amer. Soc. Agron., v. 6, no. 1, p. 24-30, 2 pl. 1914.

Kubanka led in yield, the Rysting ranking second and Ghirka third. At the other stations, under severe drought conditions, the yields decreased from the north to the south, no yields being obtained at Highmore and Newell. At Williston and Dickinson the Ghirka again yielded considerably better than the other wheats, but did not retain this advantage at the stations farther south. Early rust, as well as drought, reduced its yield at Brookings. For all stations, however, the Ghirka ranked first, Kubanka second, Rysting-Glyndon third, and Haynes fourth.

The annual and seasonal precipitation at each station for the seven years is given in Table II. The averages of these data are included also in figure 3, to aid in the interpretation of the yield data.

TABLE II.—*Annual and seasonal (April to July, inclusive) precipitation at seven experiment stations in three States of the northern Great Plains area, 1908 to 1914, inclusive.*

Station.	Precipitation (inches).							
	1908	1909	1910	1911	1912	1913	1914	Average.
Moccasin, Mont.:								
Annual	21.49	22.97	15.26	21.15	[a] 15.00	14.96	15.67	[b] 18.58
Seasonal	10.57	13.96	6.50	7.69	[a] 7.93	9.32	9.38	[b] 9.57
Williston, N. Dak.:								
Annual	13.49	11.74	10.28	13.69	16.33	14.28	18.47	14.04
Seasonal	7.00	9.05	5.48	5.70	10.20	5.63	11.98	7.86
Dickinson, N. Dak.:								
Annual	19.48	21.26	13.34	15.73	[a] 19.06	11.93	22.74	[b] 17.41
Seasonal	10.46	11.53	8.35	5.99	[a] 12.46	5.31	16.79	[b] 9.74
Edgeley, N. Dak.:								
Annual	17.07	15.14	12.21	15.47	21.84	19.82	18.05	17.09
Seasonal	9.24	10.55	4.01	6.87	15.59	9.06	13.23	9.79
Brookings, S. Dak.:								
Annual	32.34	22.34	12.78	24.95	23.18	16.58	24.15	22.33
Seasonal	19.60	10.64	6.74	10.62	14.95	10.69	14.09	12.47
Highmore, S. Dak.:								
Annual	22.37	18.03	11.15	15.87	11.16	12.46	17.52	15.51
Seasonal	12.50	8.52	6.93	5.41	6.00	8.59	11.98	8.57
Newell, S. Dak.:								
Annual	14.23	17.73	12.55	6.64	16.09	12.53	11.70	13.07
Seasonal	7.84	12.75	5.76	1.92	8.07	5.66	6.74	6.97
All stations:								
Annual	20.07	18.46	12.51	16.21	17.72	14.65	18.33	17.15
Seasonal	11.03	11.00	6.25	6.31	10.96	7.75	12.03	9.28

[a] These precipitation data are excluded from the average because the crop was destroyed by hail.
[b] Average for only 6 years, excluding 1912.

In 1912 the varieties at Moccasin and Dickinson were destroyed by hail and no yields were obtained, although very favorable conditions existed until the hail occurred. At Williston, under similar favorable conditions, unusually large yields were obtained. At Edgeley and Brookings the conditions were fair, while at Highmore and Newell the third successive droughty year occurred. The Ghirka slightly outyielded the Kubanka at Williston and also led the other varieties at Highmore and Newell. At the latter station it was the only variety of the four that produced grain, thus showing again its drought-resisting ability. Kubanka produced a yield a third greater than the other varieties at both Edgeley and Brookings, due largely to the

greater rust resistance of the durum wheat. The rank in yield of the other three varieties at these two stations was reversed. For the five stations where results were obtained the Kubanka ranked first, Ghirka second, Rysting-Glyndon third, and Haynes fourth.

The favorable season of 1913 resulted in good yields at all stations except Highmore. The Kubanka led in yield at Moccasin, Williston, and Brookings, the Ghirka at Edgeley and Newell, the Rysting at Dickinson, and the Glyndon at Highmore. For all stations the Kubanka ranked first, Ghirka second, Rysting-Glyndon third, and Haynes fourth.

The season of 1914 was favorable at Moccasin and Williston, but drought, hail, and rust reduced the yields at the other stations. The yields have been computed for certain varieties which were not grown at three stations in 1914. The Haynes was discarded at Moccasin after 1912 and the Ghirka at Brookings after 1913. The Kubanka and Ghirka were unfortunately omitted, through error, from the test at Newell in 1914. The yields at Dickinson were damaged about two-thirds by hail. Rust reduced the yields at Edgeley, Brookings, and Highmore as much or more than drought.

The Kubanka produced the best yields at Williston, Edgeley, Brookings, and Highmore and equaled the yields of Ghirka and Rysting at Moccasin. The yield of Ghirka was relatively less at all stations except Moccasin than that usually obtained. For all stations the Kubanka ranked first, Rysting-Glyndon second, Ghirka third, and Haynes fourth.

SUMMARY OF YIELDS.

The averages for the seven years from 1908 to 1914, inclusive, covering a period of varying seasonal conditions, show a remarkable uniformity of results for the different varieties at each station. The Kubanka durum leads all varieties at all stations except Dickinson. Had the comparison included the results for 1907 at Dickinson the Kubanka would have outyielded the other varieties. A selection from Kubanka called Kubanka No. 8 (C. I. No. 4063) also outyielded the other varieties at Dickinson for the 5-year period from 1910 to 1914, inclusive.

The Ghirka has ranked second at Moccasin, Williston, Edgeley, and Newell, and tied with Rysting for second rank at Brookings. At Dickinson the Ghirka was first and at Highmore fourth.

The Rysting-Glyndon ranked third at Moccasin, Williston, Highmore, and Newell and tied at Brookings for second place. At Dickinson it ranked second and at Edgeley fourth.

The Haynes gave the lowest yields at Moccasin, Williston, Dickinson, Brookings, and Newell. It ranked third at Edgeley and second at Highmore.

The yield data presented are based on 182 actual determinations (crops destroyed by hail not considered). Yields have been computed in six other cases where the varieties were not sown and actual yields, therefore, were not obtained. This makes a total of 188 tests, or 47 tests for each of the four varieties. In three of these tests no yields of grain were obtained from all or from at least three of the varieties. In five other tests, either two or three of the varieties were equal in yield.

In 39 tests the four varieties can be definitely ranked. There are 24 possible combinations in which four varieties can rank. The varieties actually ranked in 15 of the possible 24 ways in the 39 tests. In annual yield, averaged for all stations, the varieties ranked in the same order only twice during the seven seasons. This shows conflicting annual results under varying seasonal conditions.

The varieties ranked first or equaled another variety for first rank, as follows: Kubanka 24 times, Ghirka 17 times, Rysting or Glyndon 6 times, and Haynes 2 times during 44 tests.

The average acre yield in 47 comparative tests at seven stations was 18.1 bushels for Kubanka, 16.4 bushels for Ghirka, 16 bushels for Rysting-Glyndon, and 14.9 bushels for Haynes. This shows a rather definite agreement of average results under varying seasonal conditions.

It is believed that the data presented fairly indicate what may be expected in yield from these four wheats in the northern Great Plains during a series of years.

The Ghirka variety has compared favorably with standard durum, Fife, and Bluestem varieties, yielding less than the durum but more than the Fife and Bluestem varieties on an average at seven stations during a 7-year period. While it is susceptible to rust in moist seasons, it has proved more drought resistant than the other wheats here studied, outyielding all others in the dry seasons.

MILLING AND BAKING QUALITY.

Quality as well as yield is an important consideration in determining the value of a variety. Quality of wheat is thought of in many different ways. To the farmer it means grade; to the miller and baker it is the ability of a wheat to produce a high percentage of flour and a loaf of large volume. Relatively few data have been gathered on the quality of the Ghirka wheat as compared with those on yield.

Hard spring common wheats grade as No. 1 Hard, No. 1 Northern, No. 2 Northern, etc. The Ghirka wheat when marketed has been included in the Northern grade. The somewhat soft kernel prevents its ever grading as No. 1 Hard. No extensive tests have been made of the crushing point of the Ghirka kernel compared with

that of other varieties. A preliminary test, however, indicates the Ghirka to be about three-fourths as hard as the Haynes Bluestem and about one-half as hard as Kubanka durum wheat. This confirms the general opinion that Ghirka is a semi-hard rather than a hard wheat.

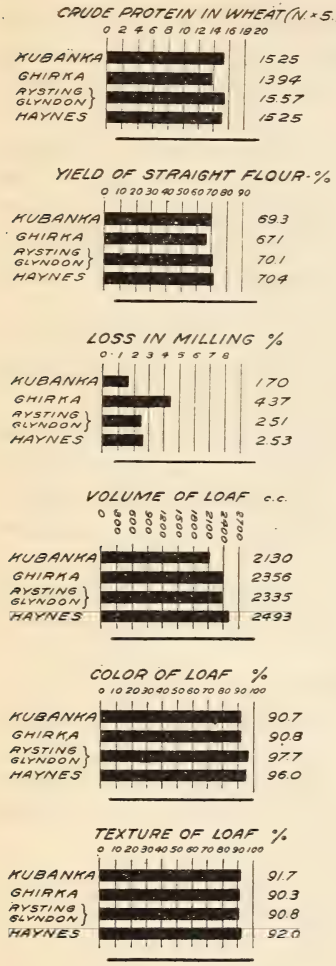
CRUDE PROTEIN IN WHEAT (N × 5.7) %
0 2 4 6 8 10 12 14 16 18 20
KUBANKA 15.25
GHIRKA 13.94
RYSTING } GLYNDON } 15.57
HAYNES 15.25
YIELD OF STRAIGHT FLOUR - %
0 10 20 30 40 50 60 70 80 90
KUBANKA 69.3
GHIRKA 67.1
RYSTING } GLYNDON } 70.1
HAYNES 70.4
LOSS IN MILLING %
0 1 2 3 4 5 6 7 8
KUBANKA 1.70
GHIRKA 4.37
RYSTING } GLYNDON } 2.51
HAYNES 2.53
VOLUME OF LOAF c.c.
0 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2700
KUBANKA 2130
GHIRKA 2356
RYSTING } GLYNDON } 2335
HAYNES 2493
COLOR OF LOAF %
0 10 20 30 40 50 60 70 80 90 100
KUBANKA 90.7
GHIRKA 90.8
RYSTING } GLYNDON } 97.7
HAYNES 96.0
TEXTURE OF LOAF %
0 10 20 30 40 50 60 70 80 90 100
KUBANKA 91.7
GHIRKA 90.3
RYSTING } GLYNDON } 90.8
HAYNES 92.0

FIG. 4.—Diagram showing the average results of milling and baking tests of four varieties of wheat grown at the Dickinson substation during 1911, 1913, and 1914.

Many milling and baking tests have been made of Ghirka wheat grown at various stations, but the methods used by the investigators have varied. For several years the Office of Cereal Investigations and the North Dakota Agricultural Experiment Station have studied the milling and baking qualities of the principal wheats grown at the Dickinson substation. During three years, 1911, 1913, and 1914, the method used was the same. These data compare the milling and baking qualities of the Ghirka with those of the wheats already compared with it in regard to yield. The data for the Ghirka, Kubanka, and Haynes varieties are strictly comparable. The results from the Rysting in 1911 and 1913 have been combined with those from the Glyndon in 1914 to make the data somewhat comparable with those on yield. The annual and average results are given in Table III. In figure 4 only the average results are shown.

In 1911, data were obtained on the yield of straight flour and on the volume, color, and texture of the loaf. The Ghirka produced the lowest yield of flour and scored lowest in texture. The loaf volume was greater than that from the Rysting and the Kubanka, and the color of the loaf was better than that from the Kubanka. The Haynes gave the highest yield of straight flour, as well as the largest volume of loaf. The Rysting had the best color and texture of loaf.

In 1913, data on the crude-protein content of the kernel and on loss in milling were obtained for the first time. In that year the Ghirka was highest in loaf volume but lowest in crude-protein con-

tent and yield of straight flour, and it showed the greatest loss in milling. The low yield of flour and the loss in milling are especially pronounced. This is partly due to a peculiar fluffiness of the Ghirka flour. The Haynes gave the highest yield of straight flour and tied Kubanka for the highest score in texture of loaf. The Rysting had the highest percentage of crude protein in the wheat and the best color of loaf.

The data for 1914 show that the Ghirka is the poorest in crude-protein content and color and texture of loaf and shows the greatest loss in milling. The Haynes leads in crude-protein content and texture of loaf. The Glyndon yields more straight flour, produces the best volume of loaf, and ties with the Haynes in color of loaf.

The 3-year average of these data shows that the Ghirka variety has not compared favorably in quality with standard Bluestem, Fife, and durum wheats. It ranks relatively low in market grade, in crude protein, color and texture of loaf, and yield of straight flour, and has a large loss in milling. The volume of loaf is usually good, although averaging less than that of Bluestem.

TABLE III.—*Milling and baking tests of Ghirka and three other varieties of wheat grown at the Dickinson (N. Dak.) substation in 1911, 1913, and 1914.*[a]

Variety.	C. I. No.	1911	1913	1914	Average.
Crude protein (N × 5.7) in wheat (per cent):					
Kubanka	1440	.....	15.50	14.99	15.25
Ghirka	1517	.....	14.36	13.52	13.94
Rysting	[b] 3022	}	15.80	15.33	15.57
Glyndon	[b] 2873				
Haynes	2874	.....	14.99	15.50	15.25
Yield of straight flour (per cent):					
Kubanka	1440	71.2	69.7	66.9	69.3
Ghirka	1517	68.7	65.3	67.3	67.1
Rysting	[b] 3022	} 71.2	70.6	68.4	70.1
Glyndon	[b] 2873				
Haynes	2874	73.5	71.2	66.6	70.4
Loss in milling (per cent):					
Kubanka	1440	.....	2.57	.82	1.70
Ghirka	1517	.....	5.94	2.80	4.37
Rysting	[b] 3022	}	3.22	1.80	2.51
Glyndon	[b] 2873				
Haynes	2874	.....	2.68	2.37	2.53
Volume of loaf (cubic centimeters):					
Kubanka	1440	1,970	1,985	2,435	2,130
Ghirka	1517	2,150	2,270	2,648	2,356
Rysting	[b] 3022	} 2,060	2,000	2,945	2,335
Glyndon	[b] 2873				
Haynes	2874	2,320	2,260	2,900	2,493
Color of loaf (per cent):					
Kubanka	1440	83	93	96.0	90.7
Ghirka	1517	85	96	91.5	90.8
Rysting	[b] 3022	} 97	99	97.0	97.7
Glyndon	[b] 2873				
Haynes	2874	95	96	97.0	96.0
Texture of loaf (per cent):					
Kubanka	1440	86	94	95.0	91.7
Ghirka	1517	85	93	93.0	90.3
Rysting	[b] 3022	} 87	90	95.5	90.8
Glyndon	[b] 2873				
Haynes	2874	86	94	96.0	92.0

[a] The grain was milled and the bread baked at the North Dakota Agricultural Experiment Station.
[b] Results for 1911 and 1913 are from Rysting (C. I. No. 3022); for 1914, from Glyndon (C. I. No. 2873).

The Haynes has the highest average yield of flour, volume of loaf, and texture of loaf. The Rysting-Glyndon has the highest average crude-protein content and color of loaf. The Kubanka shows the smallest loss in milling.

The data given show that the Haynes is superior to the Ghirka in all of the six characters studied. The Rysting-Glyndon is superior in all characters except loaf volume, and the Kubanka is superior in all characters except volume and color of loaf.

IMPROVEMENT BY SELECTION.

The high-yielding and drought-resistant power of the Ghirka wheat was early recognized at the Dickinson substation. A further improvement in the yield and quality of the variety was sought through isolating a large number of pure lines and comparing them with the

FIG. 5.—Pure-line selections of Ghirka Spring wheat growing in eightieth-acre plats at the Dickinson substation in 1913.

original. This work was started in 1909, when about 300 heads were selected from a plat of the Ghirka wheat.[1] The kernels from these were sown in head rows in 1910. Yield data were obtained, and all the best, a large number of the medium, and some of the poorest were selected for sowing in 1911. Of these selections, 104 were sown in 17-foot rows for comparative yields, with the original Ghirka mass variety used as a check every third row. Eighty of the selections were sown also in rows of varying length to increase

[1] The experiments to improve the Ghirka Spring variety by pure-line selection were suggested by Supt. L. R. Waldron, of the Dickinson substation, who has maintained his interest in the work throughout the entire period. The original selections were made by Mr. Charles H. Clark, who was in charge of the cereal work at the Dickinson substation in 1909 and 1910. From 1911 to July 25, 1914, the writer was in direct charge of the cooperative cereal experiments at Dickinson. On the latter date he was succeeded by Mr. Ralph W. Smith, who continues in charge of the work as Scientific Assistant in Cereal Investigations.

the seed. Considerable variation was observed in the different pure lines, not only in respect to yield but also in the color and texture of the kernel, morphological characters of the plant, etc.

In 1912 the same 104 selections were sown in duplicated 17-foot rows with checks. About 20 were sown also in hundredth-acre plats. These tests were all destroyed by hail.

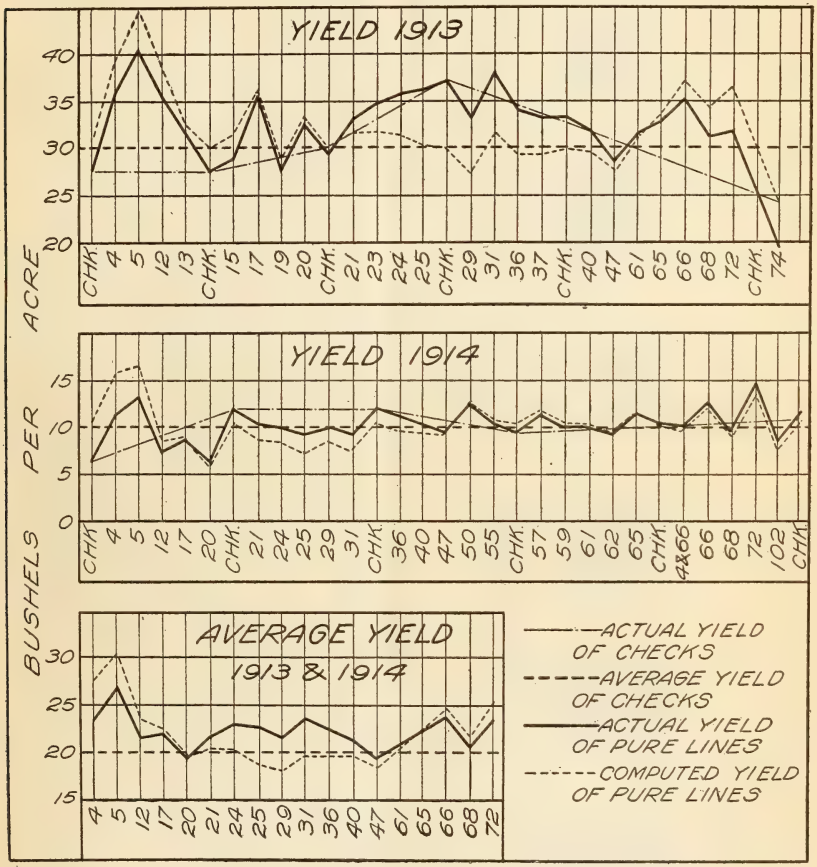

FIG. 6.—Diagram showing the annual and average actual and computed yields of Ghirka Spring wheat (C. I. No. 1517) used as a check and 30 pure lines selected therefrom, grown at the Dickinson substation in 1913 and 1914.

In 1913 the entire 104 selections were again sown in 17-foot rows from reserve stocks of seed. In addition, 86 of them were grown in 108-foot rows and 24 in plats (fig. 5) of one-eightieth acre. This series of tests gave considerable information on the behavior of these pure lines.

Samples of the grain from the 24 pure lines grown in field plats were used in milling and baking tests in cooperation with the North Dakota Agricultural Experiment Station.

In 1914 the work was continued. Besides the nursery work, 24 selections were again grown in field plats. Eighteen of these were the same as those grown in plats in 1913. The wheats were greatly damaged by hail which fell shortly before the crop was ripe. The plats were harvested, however, and yield data obtained. Milling and baking tests were also made on a number of the selections.

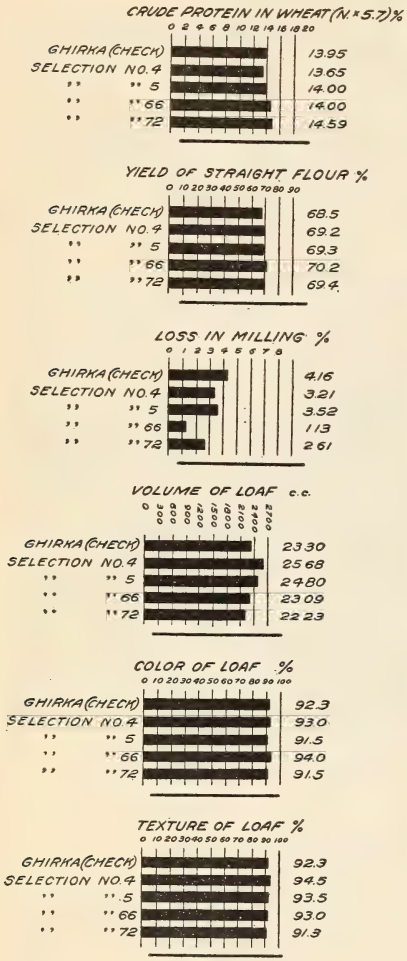

FIG. 7.—Diagram showing the average results of milling and baking tests of Ghirka Spring wheat (C. I. No. 1517) and four pure lines selected therefrom, grown at the Dickinson substation in 1913 and 1914.

The annual agronomic data for the pure lines grown in plats in 1913 and 1914 are given in Table IV, together with data from the check plats of the original Ghirka, C. I. No. 1517. In figure 6 are shown the results obtained in 1913 and 1914 and the average for the two years. The pure lines are arranged in the actual order of the sowings, and the actual and computed yields are shown separately. The actual yield of the check plats and the average for all checks are shown by different lines.

Improvement in the quality of Ghirka wheat is more important than increase in yield. It was hoped that a pure line would be found which had the combined characters necessary for good quality and high yield. A study of the milling and baking data obtained during the two years 1913 and 1914 on the highest yielding selections indicates that the desired result was obtained. These data are shown in Table V.

Figure 6 shows that in 1913 the Ghirka selections Nos. 4, 5, 17, 31, 66, and 72 were outstanding in regard to yield and that many others were better than the parent mass variety. The data for 1914 show that Nos. 4, 5, 50, 66, and 72 produced outstanding yields. An average of the yields of the pure lines grown both years shows Nos. 4, 5, 66, and 72 to be the best four selections when both actual and computed yields are considered, each showing an increase of more than

3 bushels over the parent variety. No definite conclusions can be drawn from the results of only two years, but the data indicate that improvement in yield is possible and that progress is being made. During the years covered by these data rust was not prevalent and no data were obtained on the rust-resisting ability of the different selections.

The average data for the four highest yielding pure lines and the parent mass variety are shown graphically in figure 7. The data given for the pure lines each year are an average of one milling and two bakings and for the parent variety are an average of these data from two plats, or an average of two millings and four bakings.

In 1913, Ghirka selections Nos. 4 and 66 exceeded the original Ghirka in crude-protein content and in yield of straight flour, gave a smaller loss in milling, and produced loaves of greater volume, which also scored higher in color and texture. This was an improvement in all of the characters here studied. Nos. 5 and 72 exceeded the original in some characters but failed to equal it in others.

In 1914, No. 4 gave the highest volume of loaf, but was low in crude protein and yield of straight flour, had a high loss in milling, and scored low in color. No. 66 scored low in volume of loaf and in texture, but otherwise exceeded the check. For the second year it showed an unusually low loss in milling.

Selection No. 5 led in crude protein and yield of straight flour, was superior to the original in volume and texture of loaf, and lost less in milling. Selection No. 72 was low in yield of flour and in volume, color, and texture of loaf. None of the four highest yielding pure lines exceeded the original variety in all characters in 1914.

The average for the two years shows that selection No. 4 was superior to the unselected Ghirka in all characters except crude-protein content and No. 66 in all characters except volume of loaf. No. 5 shows a decrease in crude protein and in color of loaf, while No. 72 shows a decrease in the volume, color, and texture of loaf. While none of the four best yielding selections has exceeded the mass variety in all of the characters studied, a gain in some of the characters offsets the loss in others, and the data thus far obtained indicate that at least the first three selections mentioned are superior in quality to the parent mass variety.

TABLE IV.—*Agronomic data for unselected Ghirka wheat, used as a check, and 30 pure lines selected therefrom, grown at the Dickinson (N. Dak.) substation in 1913 and 1914.*

Ghirka and selections.	C. I. No.	Date.		Planting to maturity.	Stand.		Height.	Yield per acre.				Weight per bushel.
		Headed, July—	Ripe, Aug.—		Plants per acre.	Estimated.		Actual.		Computed.		
								Grain.	Straw.	Grain.	Straw.	
					Thousands.							
Season of 1913:[1]				*Days.*		*Per ct.*	*In.*	*Bu.*	*Cwt.*	*Bu.*	*Cwt.*	*Lbs.*
Ghirka	1517	14	12	113	640	86	.....	27.3	20.4	30.0	24.6	61
Selections—												
No. 4	4413	14	12	113	696	94	32.1	35.6	25.3	39.0	31.0	62
No. 5	4414	12	9	110	776	105	34.0	40.5	23.3	44.3	28.8	62.5
No. 12	4415	12	12	113	688	93	33.4	35.3	22.4	38.7	28.0	62.5
No. 13	.....	10	10	111	844	114	34.2	31.3	19.6	32.3	25.2	61.5
Ghirka	1517	12	12	113	700	95	.....	27.3	19.2	30.0	24.6	62.3
Selections—												
No. 15	4416	16	15	116	560	76	33.2	28.8	19.8	31.3	24.3	61.5
No. 17	4417	14	12	113	724	98	34.5	35.2	21.7	36.1	25.5	62.5
No. 19	.....	12	12	113	860	116	34.3	27.7	20.2	28.9	22.9	61.5
No. 20	.....	10	9	110	692	94	32.3	32.2	23.5	33.2	25.6	61
Ghirka	1517	12	12	113	700	95	.....	29.5	23.5	30.0	24.6	62
Selections—												
No. 21	.....	12	12	113	608	82	32.4	33.0	24.3	31.8	24.1	62
No. 23	4418	14	12	113	868	117	35.0	34.7	25.6	31.9	24.2	62.5
No. 24	4419	14	12	113	728	98	34.0	36.0	25.2	31.6	22.6	61.5
No. 25	4420	14	12	113	840	113	34.3	36.2	26.9	30.4	22.2	62
Ghirka	1517	12	12	113	680	92	.....	37.2	30.1	30.0	24.6	62.5
Selections—												
No. 29	4421	10	9	110	860	116	32.3	33.2	25.7	27.3	21.5	61
No. 31	.....	12	12	113	768	104	32.7	38.0	29.2	31.9	25.0	62
No. 36	.....	12	12	113	820	111	32.3	34.1	28.0	29.3	24.5	62.5
No. 37	.....	12	12	113	836	113	31.8	33.3	26.0	29.3	23.3	62
Ghirka	1517	12	12	113	648	88	.....	33.3	26.8	30.0	24.6	62
Selections—												
No. 40	4422	12	12	113	768	104	31.7	32.0	23.2	29.7	21.2	62
No. 47	.....	12	13	114	752	102	30.4	28.8	27.9	27.6	25.4	61
No. 61	.....	12	9	110	688	93	34.3	31.7	26.7	31.4	24.1	62
No. 65	4424	14	9	110	896	121	33.4	33.0	25.9	33.8	23.4	61.5
No. 66	4425	12	12	113	828	112	31.6	35.2	25.9	37.3	23.1	61.5
No. 68	4426	10	10	111	792	107	.....	31.3	22.0	34.5	19.7	60.5
No. 72	4427	11	12	113	720	97	33.9	32.0	25.6	36.6	22.9	62.5
Ghirka	1517	12	12	113	684	92	.....	25.2	27.7	30.0	24.6	61
Selections—												
No. 74	.....	12	12	113	524	71	34.2	19.3	17.6	24.0	22.8	61
Season of 1914:[2]												
Ghirka	1517	10	8	112	616	114	41.5	6.4	17.3	10.3	19.0	51
Selections—												
No. 4	4413	10	8	112	532	99	.....	11.2	20.2	15.8	21.6	52.5
No. 5	4414	10	8	112	454	84	37.2	13.2	25.7	16.4	26.9	52.5
No. 12	4415	10	8	112	436	81	39.8	7.6	9.8	8.5	10.1	53
No. 17	4417	10	8	112	490	91	39.2	8.8	9.1	9.0	9.1	51.5
No. 20	.....	10	8	112	460	85	36.7	6.4	24.0	5.9	23.6	49
Ghirka	1517	10	8	112	596	110	41.5	12.0	19.7	10.3	19.0	.....
Selections—												
No. 21	.....	12	8	112	460	85	39.9	10.4	20.6	8.9	20.1	53
No. 24	4419	10	8	112	464	86	39.9	10.0	23.8	8.6	23.2	51.5
No. 25	4420	10	8	112	440	82	41.1	9.2	20.4	7.2	20.2	52
No. 29	4421	8	8	112	456	85	39.2	10.0	19.0	8.6	18.9	49
No. 31	.....	10	8	112	472	87	39.4	9.2	17.5	7.2	17.6	52
Ghirka	1517	10	8	112	644	119	39.8	12.0	18.7	10.3	19.0	52
Selections—												
No. 36	.....	10	8	112	552	102	41.9	11.2	22.1	9.9	22.1	51.5
No. 40	4422	11	8	112	472	87	40.2	10.4	28.3	9.6	28.0	52
Selections—												
No. 47	.....	10	8	112	644	119	38.1	9.6	15.4	9.2	15.0	51.5
No. 50	4423	9	8	112	636	118	40.3	12.8	25.0	12.7	24.1	52
No. 55	.....	9	8	112	580	108	41.3	10.4	23.5	10.7	22.4	53.5
Ghirka	1517	10	8	112	604	112	40.4	9.6	20.2	10.3	19.0	51.5
Selections—												
No. 57	.....	9	8	112	628	116	43.5	11.2	19.2	11.9	18.7	52
No. 59	.....	11	8	112	532	99	38.8	10.0	27.6	10.4	27.9	51
No. 61	.....	10	8	112	592	110	40.9	10.0	17.0	10.3	18.0	53
No. 62	.....	10	8	112	516	96	40.7	9.2	22.3	9.4	24.5	50.5
No. 65	4424	10	8	112	544	101	37.1	11.2	20.2	11.2	23.1	51
Ghirka	1517	10	8	112	512	95	41.6	10.4	15.8	10.3	19.0	52
Selections—												
Nos. 4 and 66	.....	9	8	112	528	98	40.1	10.0	21.8	9.8	24.5	52.5
No. 66	4425	9	8	112	584	108	42.6	12.4	27.1	12.0	28.8	52.5
No. 68	4426	10	8	112	524	97	39.2	9.6	18.2	9.2	18.2	51
No. 72	4427	10	8	112	496	92	.....	14.4	29.8	13.6	28.2	51.5
No. 102	.....	14	8	112	664	123	.....	8.4	24.7	7.8	22.3	49
Ghirka	1517	11	8	112	596	110	42.4	11.2	22.1	10.3	19.0	52.5

[1] Sown Apr. 21, emerged May 10, harvested Aug. 15, 1913.
[2] Sown Apr. 18, emerged May 2, harvested Aug. 10, 1914.

TABLE V.—*Milling and baking data for Ghirka wheat, used as a check, and 25 pure lines selected therefrom, grown at the Dickinson (N. Dak.) substation in 1913 and 1914.*

Plat No.	Variety.	C. I. No.	Crude protein in wheat (N×5.7).	Yield of flour.	Loss in milling.	Loaf.		
						Volume.	Color.	Texture.
	Season of 1913:							
	Selections—		*Per ct.*	*Per ct.*	*Per ct.*	*C. c.*	*Per ct.*	*Per ct.*
2	No. 4	4413	14.36	71.2	3.35	2,450	96	94
3	No. 5	4414	13.45	69.6	5.65	2,300	94	93
4	No. 12	4415	14.42	68.7	4.75	2,320	92	94
5	No. 13	.....	14.99	67.1	5.78	2,130	84	88
7	No. 15	4416	15.28	69.9	7.39	1,860	92	88
8	No. 17	4417	13.97	68.5	5.14	2,200	99	92
9	No. 19	.....	15.28	69.1	4.50	2,265	96	93
10	No. 20	.....	16.07	68.9	5.10	1,885	90	90
12	No. 21	.....	14.82	70.5	2.85	2,155	94	92
13	No. 23	4418	14.36	69.8	4.50	2,150	89	90
14	No. 24	4419	14.54	67.2	5.98	2,350	89	94
15	No. 25	4420	15.16	70.3	4.01	2,065	89	90
17	No. 29	4421	15.62	67.5	7.10	1,790	94	86
18	No. 31	.....	15.28	70.1	4.17	1,985	90	92
19	No. 36	.....	15.16	69.8	4.32	2,030	91	90
20	No. 37	.....	14.54	70.4	4.57	1,895	86	90
22	No. 40	4422	14.54	72.0	3.10	2,120	95	93.5
23	No. 47	.....	14.88	70.7	4.77	2,110	96	93
24	No. 61	.....	14.71	69.2	5.73	2,080	93	93
25	No. 65	4424	14.48	68.9	5.17	2,050	94	94
26	No. 66	4425	14.76	72.4	1.46	2,097	95	93.5
27	No. 68	4426	15.50	67.2	7.68	1,825	89	85
28	No. 72	4427	14.99	72.2	3.49	1,975	92	92
30	No. 74	.....	14.71	71.7	4.21	1,895	90	89
21, 29	Ghirka	1517	13.88	69.6	5.51	2,011	93	91.5
	Season of 1914:							
	Selections—							
2	No. 4	4413	12.94	67.2	3.06	2,685	90	95
3	No. 5	4414	14.54	69.0	1.39	2,660	89	94
9	No. 24	4419	13.22	66.9	2.67	2,675	94	92
11	No. 29	4421	13.97	66.0	2.06	2,590	90	92
15	No. 40	4422	14.36	65.7	2.60	2,320	93	89
17	No. 50	4423	14.71	68.0	1.80	2,405	93	90
27	No. 66	4425	14.36	67.9	.80	2,520	93	92.5
29	No. 72	4427	14.19	66.5	1.73	2,470	91	90.5
13, 25	Ghirka	1517	14.02	67.3	2.80	2,648	91.5	93

A comparison of these three pure lines with standard varieties will serve to show their relative values. Five such varieties have been grown and a comparison is made of their annual and average yields per acre, percentages of straight flour, and volumes of loaf in Table VI. While the data on yield are not strictly comparable, owing to the difference noted in the size of plats, they show that the selections possess the ability to produce comparatively high yields. In percentage of straight flour the average shows that selection No. 66 exceeds any of the other varieties studied, while selections Nos. 5 and 4 exceed the Haynes, Marquis, and Red Fife. In volume of loaf the Haynes slightly exceeds selection No. 4, which, in turn, is superior to the Red Fife, Preston, Marquis, and Kubanka, while selection No. 5 is superior to the Preston, Marquis, and Kubanka, and selection No. 66 is superior to the Kubanka.

These selections and several others are being further tested to determine more accurately their true value before any are distributed.

TABLE VI.—*Yields of grain and of flour and volumes of loaf obtained from three pure-line selections of Ghirka and five standard varieties of hard spring wheat grown at the Dickinson (N. Dak.) substation in 1913 and 1914.*

[The varieties are arranged in the order of their average yields.]

Variety.	C. I. No.	1913	1914	Average.
Yield per acre (bushels):				
Ghirka No. 5	4414	[a] 40.5	[b] 13.2	26.9
Ghirka No. 66	4425	[a] 35.2	[b] 12.4	23.8
Ghirka No. 4	4413	[a] 35.7	[b] 11.2	23.5
Kubanka	1440	[c] 31.2	[d] 14.2	22.7
Red Fife	3329	[c] 28.3	[d] 10.2	19.3
Preston	3081	[c] 25.6	[d] 12.9	19.3
Marquis	3641	[c] 24.0	[d] 14.0	19.0
Haynes	2874	[c] 24.8	[d] 8.3	16.6
Yield of straight flour (per cent):				
Ghirka No. 66	4425	72.4	67.9	70.2
Kubanka	1440	71.8	66.9	69.4
Preston	3081	70.7	68.1	69.4
Ghirka No. 5	4414	69.6	69.0	69.3
Ghirka No. 4	4413	71.2	67.2	69.2
Haynes	2874	71.2	66.6	68.9
Marquis	3641	69.2	63.8	66.5
Red Fife	3329	71.8	60.0	65.9
Volume of loaf (cubic centimeters):				
Haynes	2874	2,260	2,900	2,580
Ghirka No. 4	4413	2,450	2,685	2,568
Red Fife	3329	2,220	2,775	2,498
Ghirka No. 5	4414	2,300	2,660	2,480
Preston	3081	2,170	2,785	2,478
Marquis	3641	2,250	2,475	2,363
Ghirka No. 66	4425	2,097	2,520	2,309
Kubanka	1440	1,985	2,435	2,210

[a] Plats one-eightieth of an acre.
[b] Plats one forty-eighth of an acre.
[c] Plats one-tenth of an acre.
[d] Plats one forty-eighth of an acre, replicated four times.

It is possible that a mixture of two or three of the best selections may result in a further improvement in yield or quality. A preliminary test to determine this, combining selections Nos. 4 and 66, is already under way. Crosses have been made between these best pure lines and other varieties of hard spring common wheat, and promising selections of the progeny of the second and fourth generations are now in existence. From these a still further improvement in quality and in rust resistance is expected, while retaining the high-yielding and drought-resistant qualities of the Ghirka wheat.

CONCLUSIONS.

Ghirka Spring wheat, a variety of commercial importance in Russia, has proved adapted to the northern part of the Great Plains area of the United States. The variety is susceptible to rust in moist seasons and in humid areas, but it has proved to be a valuable drought-resistant wheat.

Tests at seven experiment stations in the northern Plains area, covering a period of seven years, have shown that on an average the Ghirka Spring has yielded more than the Rysting Fife and Haynes Bluestem common wheats, but less than the Kubanka durum wheat. The quality of the Ghirka, however, is inferior to that of these standard wheats.

Experiments are being made at the Dickinson (N. Dak.) substation to improve both the yield and the quality of the Ghirka wheat by isolating superior pure lines. Many pure lines have been tested, and among them selections Nos. 4, 5, and 66 have thus far proved superior to the others and to the original mass variety in both yield and quality. They also compare favorably with the standard spring wheats of the Great Plains area in quality as well as in yield. The selections are also proving valuable material for crossing with varieties possessing greater rust resistance and high quality of grain.

From the data given it is shown that improvement in yield and quality is possible from pure-line selection and that good results are being obtained.

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